A GPS ephemeris data issue identifier is generated at block 206 for each assistance message having new ephemeris data. The GPS ephemeris data issue identifier is only updated when the GPS ephemeris data updated. Particularly, the GPS ephemeris data issue identifier is not updated when parameters other than the GPS ephemeris data are updated or changed. In some embodiments, the ephemeris assistance message is updated only when the ephemeris data is updated.

In one embodiment, the GPS ephemeris data issue identifiers for each of the plurality ephemeris assistance messages are encoded in a corresponding sequence of binary digits. The sequence of binary digits also identifies the particular satellite from which the ephemeris data referenced by the ephemeris data identifier was obtained.

FIG. 3 illustrates the trajectories of first and second satellites SV1 and SV2 rising above and setting below the horizon and the corresponding periodic ephemeris data transmissions, 0-4.

In FIG. 4, the ephemeris message has at least an 8 bit data field wherein 4 data bits are for a satellite identifier that identifies a particular GPS satellite and the other 4 data bits identify the GPS ephemeris data issue associated with the identified satellite. There are a sufficient number of unique binary satellite identifiers (16) to identify each of the 8-12 satellites of the GPS constellation observable at any given time.

In FIG. 5, an alternative GPS ephemeris data issue identifier for transmission to a GPS enabled mobile station in a cellular communications network comprises a first binary data field with at least 5 bits for satellite identifier data, and a second binary data field with at least 3 bits for an ephemeris sequence

number (ESN). Preferably, the ESN is incremented only when the ephemeris data for the corresponding satellite is updated.

In the 3rd generation (W-CDMA/UMTS) architecture, the GPS assistance message with the ephemeris and clock correction data and other parameters is the SIB, and the GPS ephemeris data identifier and corresponding satellite identifier is and encoded in a generalized value tag included in the Master Information Block (MIB).

In FIG. 2, the GPS ephemeris data issue identifier is transmitted over the cellular communications network at block 208, and received and read by a mobile station (MS) at block 210. The mobile station compares the GPS ephemeris data issue identifier with any GPS ephemeris data issue identifier stored previously at the mobile station for the corresponding ephemeris data at block 212. In one embodiment, the mobile station reads a new assistance message transmitted by the network only if the new GPS ephemeris data issue identifier is different than the stored GPS ephemeris data issue identifier at block 214 or there are no stored GPS ephemeris data issue identifier and ephemeris data.

FIG. 6 illustrates a process flow diagram 600 for updating a GPS almanac data issue identifier transmitted to a GPS enabled mobile station in a cellular communications network. Generally, a reference node, illustrated in FIG. 1, receives almanac and other data from GPS satellites at block 602.

An almanac assistance message is generated including almanac and other data and other parameters, some of which may be provided by the network, at block 604. The same almanac data is provided by all GPS satellites and therefore, unlike the case of ephemeris data, it is not necessary to generate a separate almanac assistance message for each satellite.

The almanac data are updated at some known transmission interval, approximately 18 hours, also at block 602. Other data and parameters, for example transmission time as shown later as the first parameter of Tables 2 and 3, may be updated more frequently. The almanac assistance message is updated based on the updated almanac and other data and parameters at block 604.

A GPS almanac data issue identifier is generated at block 606 for the almanac assistance message. In one embodiment of the invention, the GPS almanac data issue identifier is updated only when the GPS almanac data is updated. Particularly, the GPS ephemeris data issue identifier is not updated when parameters other than the GPS almanac data are updated or changed. In some embodiments, the almanac assistance message is updated only when the almanac data is updated.

The GPS almanac data issue identifier is transmitted over the cellular communications network at block 608, and received by a mobile station (MS) at block 610. The mobile station compares the GPS almanac data issue identifier with any GPS almanac data issue identifier stored previously at the mobile station for the almanac data at block 612. The mobile station reads a new almanac assistance message transmitted by the network if the GPS almanac data issue identifier is different than the stored GPS almanac data issue identifier at block 614 or there are no stored GPS almanac data issue identifier and almanac data .

In one embodiment, the GPS almanac data issue identifier is for a cell. The GPS almanac data identifier for the cell is encoded in at least a 2 bit binary data field, which may be updated by incrementing when the almanac data in the reference node is updated. In second embodiment, the GPS almanac data issue identifier is for a Public Mobile Land Network (PLMN). The GPS almanac data identifier for the PLMN is encoded in at least an 8 bit binary data field, which

may also be updated by incrementing when the almanac data in the reference node is updated. In third embodiment, the GPS almanac data set occurrence identifier and the GPS almanac data identifier are used as a generalized identifier for the PLMN . The GPS almanac data set occurrence identifier is encoded in at least a 4 bit binary field and the GPS almanac data identifier is encoded in at least a 4 bit binary filed.

In the 3rd generation (W-CDMA/UMTS) architecture, the GPS assistance message with the almanac and other data and parameters is an SIB, and the GPS almanac data identifier and corresponding GPS almanac data set occurrence identifier is encoded in a generalized value tag included in the Master Information Block (MIB).

In another embodiment of the invention, real-time GPS satellite integrity data is provided in a sequence of binary bits transmitted from the network to the mobile station, such as failed/failing satellite IDs. In one embodiment, the real-time integrity data is encoded in a value tag in a master information block (MIB).

Table 1 below illustrates parameters in an exemplary GPS ephemeris assistance message.

Table 1: Exemplary Content of the Ephemeris and Clock Correction Assistance Message

Parameter	Description	Units
Transmission TOW	Approximate GPS time of week when this message is transmitted	secs
SVID	Satellite ID	

TLM Message	Telemetry Message	
TLM Reserved (C)		
HOW	Handover Word	
WN	Week Number	weeks
C/A or P on L2	Code(s) on L2 Channel	
URA Index	User Range Accuracy	
SV Health	Health Synopsis	
IODC	Issue of Data, Clock	
L2 P Data Flag		
SF1 Revered		
T_{GD}	Correction for group delay	secs
t_{oc}	Time of applicability of clock corrections	secs
A_{f2}	Second order clock correction coefficient	$secs/sec^2$
A_{f1}	First order clock correction coefficient	secs/sec
A_{f0}	Zero order clock correction	secs
C_{rs}	Radial correction coefficient	meters
Δn	Correction to mean motion	semi-circles/sec
M_0	Mean anomaly	semi-circles
C_{uc}	Argument of latitude correction coefficient	radians
E	Eccentricity	
C_{us}	Argument of latitude correction coefficient	radians
$(A)^{1/2}$	Square root of semi-major axis	$meters^{1/2}$
t_{oe}	Time of applicability of ephemeris	secs
Fit Interval Flag		
AODO		
C_{ic}	Inclination correction coefficient	radians
Ω_0	Nominal longitude of ascending node	semi-circles
C_{is}	Inclination correction coefficient	radians
i_0	Nominal inclination	semi-circles

C_{rc}	Radial correction coefficient	meters
ω	Argument of perigee	semi-circles
Ωdot	Rate of change of right ascension	semi-circles/sec
Idot	Rate of change of inclination	semi-circles/sec

Alternatively failed or failing satellites IDs detected by a real-time integrity monitor function at the network can be included in the end of the assistance message. Furthermore, they can be included in other assistance messages or be transmitted from the network to the handsets as an independent message.

There is one parameter in the ephemeris data that indicates the age of the current ephemeris data issue, i.e., time of ephemeris (t_{oe}) applicability. It should be noted that typically, a GPS satellite's time of ephemeris (t_{oe}) is two hours ahead of the current time "t" when it is initially made available by the satellite and can subsequently be made available to GPS enabled mobile stations. Consequently, a value of $t-t_{oe}$ of 2 hours corresponds to a possible four (4) hour period of use of the same ephemeris set (-2 hours <= $t- t_{oe}$ <= +2 hours) indicating a four hour fit interval for each ephemeris set. Accordingly, one can push the period of applicability of any particular ephemeris set to 5 hours ($t- t_{oe}$ = +3 hours) or more with very little affect on the satellite position and velocity error. In addition, this error is completely removed by tailored DGPS corrections for the entire satellite visibility pass. Table 4 below shows the content of the tailored DGPS corrections.

As a result discussed above, $t-t_{oe}$ age limit can be used by the handset to determine when it is necessary to read the cellular network transmitted ephemeris data again. The ephemeris assistance messages transmitted by the network may thus be ignored until the stored ephemeris set reaches its age limit, for example where the broadcast frequency of the ephemeris assistance messages are greater

CLAIMS

1. A method for updating a GPS ephemeris data issue identifier transmitted to a GPS enabled mobile station in a cellular communications network, comprising:

receiving GPS ephemeris data at a reference node in communication with a cellular communications network;

generating an assistance message including GPS ephemeris data and other parameters;

generating a GPS ephemeris data issue identifier;

receiving updated GPS ephemeris data and other updated parameters;

updating the GPS ephemeris data issue identifier only when the GPS ephemeris data has been updated.

2. The method of Claim 1, not updating the GPS ephemeris data issue identifier when parameters other than the GPS ephemeris data change.

3. The method of Claim 1, transmitting a GPS ephemeris data issue identifier over the cellular communications network, receiving the GPS ephemeris

data issue identifier at a mobile station, comparing the received GPS ephemeris data issue identifier with a corresponding GPS ephemeris data issue identifier stored at the mobile station, reading a corresponding ephemeris assistance message at the mobile station only if the received GPS ephemeris data issue identifier is different than the stored GPS ephemeris data issue identifier.

4. The method of Claim 1,

receiving GPS ephemeris data from a plurality of satellites at a reference node in communication with a cellular communications network;

generating a plurality of assistance messages including GPS ephemeris data from the plurality of satellites and other parameters;

generating a GPS ephemeris data issue identifier for each of the plurality of assistance messages;

updating the plurality of GPS ephemeris data issue identifiers only when the GPS ephemeris data of the corresponding assistance message has been updated.

5. The method of Claim 4, encoding each of the GPS ephemeris data issue identifiers and a corresponding satellite identifier in a corresponding sequence of binary digits, transmitting the sequence of binary digits over the network.

6. A method for updating a GPS almanac data issue identifier transmitted to a GPS enabled mobile station in a cellular communications network, comprising:

receiving GPS almanac data at a reference node in communication with a cellular communications network;

generating an assistance message including GPS almanac data and other parameters;

generating a GPS almanac data issue identifier;

receiving updated GPS almanac data and other updated parameters;

updating the GPS almanac data issue identifier only when the GPS almanac data has been updated.

7. The method of Claim 6, not updating the GPS almanac data issue identifier when parameters other than the GPS almanac data change.

8. The method of Claim 6, transmitting a GPS almanac data issue identifier over the cellular communications network, receiving the GPS almanac data issue identifier at a mobile station, comparing the received GPS almanac data issue identifier with a GPS almanac data issue identifier stored at the mobile station, reading an almanac assistance message at the mobile station only if the

received GPS almanac data issue identifier is different than the stored GPS almanac data issue identifier.

9. The method of Claim 6, GPS almanac data issue identifier is for a cell, updating the GPS almanac data issue identifier by incrementing a 2-bit data field when the almanac data in the reference node is updated.

10. The method of Claim 6, GPS almanac data issue identifier for a Public Mobile Land Network (PLMN) value tag, updating the value tag by incrementing an 8-bit data field when the almanac data is in the reference node is updated.

11. A master information block (MIB) for indicating to a GPS enabled mobile station in a cellular communications network changes in a corresponding system information block (SIB) having ephemeris data and correction clock data and other parameters, comprising:

an ephemeris value tag,

the ephemeris value tag dependent only on changes in GPS ephemeris data in the corresponding SIB,

the ephemeris value tag independent of the correction clock data and any other parameters of the corresponding SIB.

12. The MIB of Claim 11/the ephemeris value tag having at least an 8-bit data field, 4 data bits identifying a corresponding satellite and 4 data bits identifying a GPS ephemeris data issue.

13. A master information block (MIB) for indicating to a GPS enabled mobile station in a cellular communications network changes in a corresponding system information block (SIB) having almanac data and other parameters, comprising:

an almanac value tag,

the almanac value tag dependent only on changes in GPS almanac data in the corresponding SIB,

the almanac value tag independent of any other parameters of the corresponding SIB.

14. The system information block of Claim 15/the almanac value tag is for a Public Mobile Land Network (PLMN), the almanac value tag having at least an 8-bit data field.

15. The system information block of Claim 14, 4 data bits identifying a corresponding satellite and 4 data bits identifying a GPS almanac data issue.

16. A GPS ephemeris data issue identifier for transmission to a GPS enabled mobile station in a cellular communications network, comprising:

a first field with satellite identifier data; and

a second field with an ephemeris sequence number.

17. The GPS ephemeris data issue identifier of Claim 16, the first field is at least 5 bits, the second field is at least 3 bits.

18. The GPS ephemeris data issue identifier of Claim 16, is a broadcast message.

19. A master information block (MIB) for transmission to a GPS enabled mobile station in a cellular communications network, comprising:

a value tag having a sequence of binary bits,

at least one combination of the binary bit indicates real-time GPS satellite integrity data.

21. A method for updating GPS ephemeris data in a cellular communications network mobile station, comprising:

obtaining ephemeris data by reading an ephemeris assistance message at the mobile handset;

evaluating validity of the ephemeris data in the mobile station by determining an age of the ephemeris data;

updating the ephemeris data by reading a new ephemeris assistance message when the stored ephemeris data reaches certain age.

22. The method of Claim 21, determining the age of the ephemeris data by: $t - t_{oe}$, where "t" is the current time and "t_{oe}" is the Time of Ephemeris.

23. A method for updating GPS almanac data in a cellular communications network mobile station, comprising:

obtaining almanac data by reading an almanac assistance message at the mobile handset;

evaluating validity of the almanac data in the mobile station by determining an age of the almanac data;

updating the almanac data by reading a new almanac assistance message when the stored almanac data reaches certain age.

23. 24. The method of Claim 22, determining the age of the almanac data by: $t - t_{oa}$, where "t" is the current time and "t_{oa}" is the Time of Almanac.